PERFORMANCE EVALUATION AND POLLUTION EMISSION CHARACTERISTICS OF FOUR STROKE DIESEL ENGINE FILLED WITH BIODIESEL

B Arun kumar[1], G Mohan[2], K S Sirisha[3], K S Haritha Vaishnavi[4], A N S Surya prakash[5]

[1,2,3,4] *UG student, Department of Mechanical Engineering, AIET, Andhra Pradesh, India.*
[5]*Asst.Professor, Department of Mechanical Engineering, AIET, Andhra Pradesh, India.*

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Abstract - *As crude oil price reaches high, the need for developing alternate fuels has become acute. Alternate fuels should be economically attractive in order to compete with currently used fossil fuels. In this work, biodiesel (ethyl ester) was prepared from mustard oil. Methanol with potassium hydroxide as a catalyst was used for the transesterification process. The biodiesel was characterized by its physical and fuel properties including density, viscosity, flash point according to ASTM standards. Production of biodiesel from mustard oil for diesel substitute is particularly important because of the decreasing trend of economical oil reserves, environmental problems caused due to fossil fuel use and the high price of petroleum products in the international market.*

The performance evaluation of a single cylinder four stroke VCR diesel engine has been done when fuelled with different blends of diesel and biodiesel made of mustard oil. It was found that brake thermal efficiency and SFC of engine slightly increases and with the increase in percentage of biodiesel.

Exhaust gas analysis indicates that with the use of biodiesel, the percentage of CO and CO_2 decreases and percentage of O_2 increases which is a good sign as far as ecological conservation is concerned.

***Key Words*: Transesterification, Biodiesel, Blend, Mustard oil, Pollution.**

1. INTRODUCTION

Increasing uncertainty about global energy production and supply, environmental concerns due to the use of fossil fuels, and the high price of petroleum products are the major reasons to search for alternatives to petrol / diesel. Scientists claimed that the global supply of oil and natural gas from the conventional sources is unlikely to meet the growth in energy demand over the next 25 years. In this perspective, considerable attention has been given towards the production of biodiesel as a diesel substitute. Moreover, biodiesel fuel has become more attractive because of its environmental benefits due to the fact that plants and vegetable oils and animal fats are renewable biomass sources. Biodiesel represents a largely closed carbon dioxide cycle (approximately 78%), as it is derived from renewable biomass sources. Compared to petroleum diesel, biodiesel has lower emission of pollutants, it is biodegradable and enhances the engine lubricity and contributes to sustainability Biodiesel has a higher cetane number than diesel fuel, no aromatics, no sulfur, and contains 10 – 11% oxygen by weight. Use of neat (unprocessed) vegetable oils in the compression ignition engines is reported to cause several problems due to its high viscosity. Biodiesel which is accepted as an attractive alternative fuel, is prepared by transesterification of vegetable oils and animal fats with an alcohol in presence of a catalyst. However, the land use for production of edible oil for biodiesel feedstock competes with the use of land for food production. Moreover, the price of edible plant and vegetable oils is usually higher than petrol / diesel. The use of waste cooking oil as biodiesel feedstock reduces the cost of biodiesel production since the feedstock costs constitutes approximately 70-95% of the overall cost of biodiesel production. Hence, the use of mustard oil should be given higher priority over the edible oils as biodiesel feedstock.

2. LITERATURE SURVEY

Chatpalliwarl, Deshpande, Modak and Thakur (2011) described the brief overview of the Biodiesel production plant. Various issues-sources, opportunities, challenges, plant design, and evaluation etc. are discussed related to the Biodiesel production. Important contribution of the presented work is- it discusses the important issues concerned with the Biodiesel production plant design, it provides the fundamental details required for the formulation of Biodiesel plant design problem, also it presents possible approach for the mathematical model to evaluate the Biodiesel plant design.

3. EXPRIMENTAL SETUP

The setup consists of single cylinder, four stroke, Multi-fuel, research engine connected to eddy current type dynamometer for loading. Setup is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The set up has stand-alone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and hardware interface. Rotameters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement. The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Rotameter was used for measuring cooling water and calorimeter water flow. Thermocouples were used for measurement of temperature of exhaust gas, cooling water and calorimeter inlet and outlet. The engine was coupled with Indus five gas exhaust analyser which is used for measuring exhaust gas emissions like CO, CO_2 and O_2.

Fig-1: Test Setup

4. EXPERIMENTAL PROCEDURE

Before starting the engine, the condition of the engine oil was checked and also the availability of water was ensured. Initially, engine was allowed to run with diesel fuel at no load till engine condition stabilizes. The engine was then tested for different loads at compression ratio set by manufacturer. For each load the engine was run for 4-5 minutes till engine parameters stabilizes. At every load was repeated for three times and readings were averaged. Simultaneously the values of CO_2,CO,NO_X, HC and O_2 were recorded by using exhaust gas analyzer.

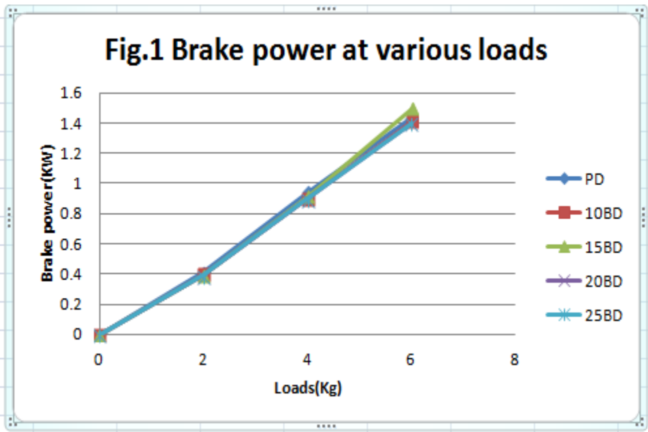
5. RESULTS

5.1 Performance Parameters:

(a) Brake Power: While comparing BP of engine with pure diesel, BP of engine when running with various blends of biodiesel and diesel is slightly reduced (5 % only).

Table -1: BP of the engine at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	0	0	0	0	0
2	0.409	0.3964	0.395	0.39	0.39
4	0.943	0.9	0.914	0.9	0.9
6	1.44	1.41	1.496	1.4	1.4

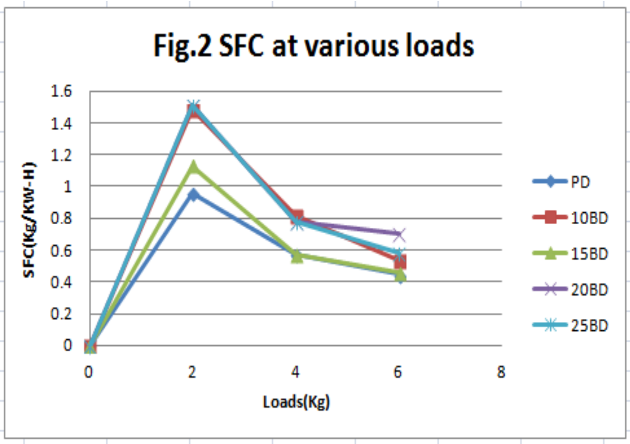


Graph -1: BP of the engine at various loads

(b) Specific fuel consumption: It deceases with the increase in % biodiesel.

Table -2: SFC of the engine at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	0	0	0	0	0
2	0.96	1.48	1.13	1.51	1.51
4	0.57	0.82	0.57	0.78	0.78
6	0.46	0.54	0.46	0.7	0.58

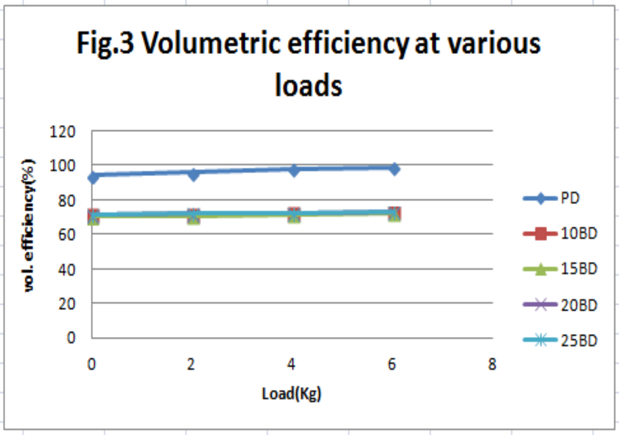


Graph -2: SFC of the engine at various loads

(c) Volumetric Efficiency: It decreases by 21 % with the increase in % of biodiesel.

Table -3: volumetric Efficiency of the engine at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	94	71.1	70.2	71	71.26
2	96	71.74	70.9	72	72.05
4	98	72.34	71.2	72.5	72.5
6	98.6	72.61	72	73.2	72.9

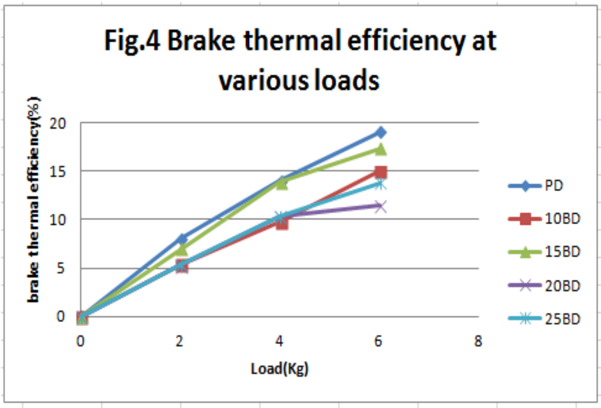


Graph -3: Volumetric Efficiency at different loads

(d) Brake Thermal Efficiency: It increases with the increase in % of biodiesel.

Table -4: BTE of the engine at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	0	0	0	0	0
2	8	5.39	7	5.3	5.31
4	14	9.79	13.9	10.3	10.30
6	19	15	17.33	11.43	13.81



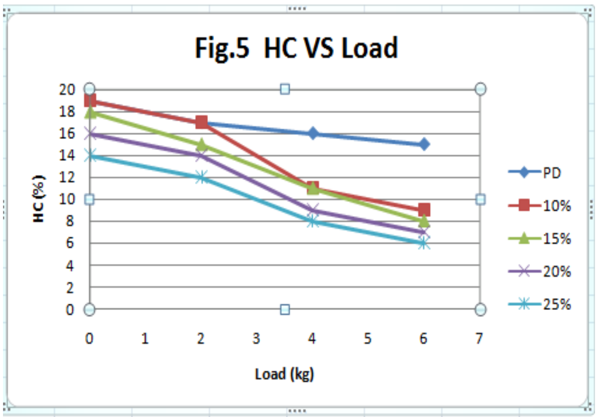
Graph -4: BTE at various loads

5.2 Emission Parameters

(a). % of HC: it decreases with the increase in biodiesel by 5%.

Table -5: % of HC at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	19	19	18	16	14
2	17	15	15	14	12
4	19	11	11	9	8
6	18	8	8	7	6

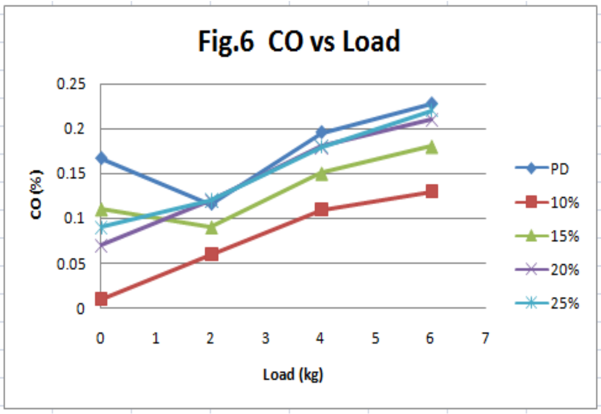


Graph -5: % of HC at different loads

(b). % of CO: It decreases with % increase in biodiesel by 27 %.

Table -6: %of carbon mono oxide

LOAD	PD	10BD	15BD	20BD	25BD
0	0.267	0.01	0.05	0.01	0.09
2	0.116	0.06	0.12	0.12	0.12
4	0.96	0.11	0.15	0.18	0.18
6	0.072	0.13	0.28	0.21	0.22

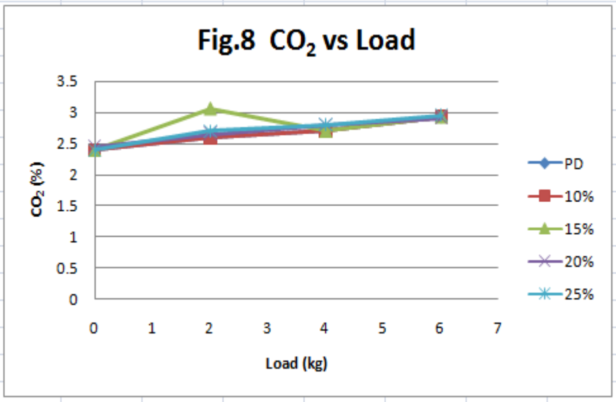


Graph -6: % of CO at different loads.

(c) % of CO_2: It decreases with the % increase in biodiesel by 2 %.

Table -7: % of CO_2 at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	2.39	2.4	2.39	2.4	2.39
2	2.66	2.6	2.66	2.66	2.66
4	2.8	2.79	2.8	2.85	2.8
6	2.93	2.93	2.9	2.93	2.93

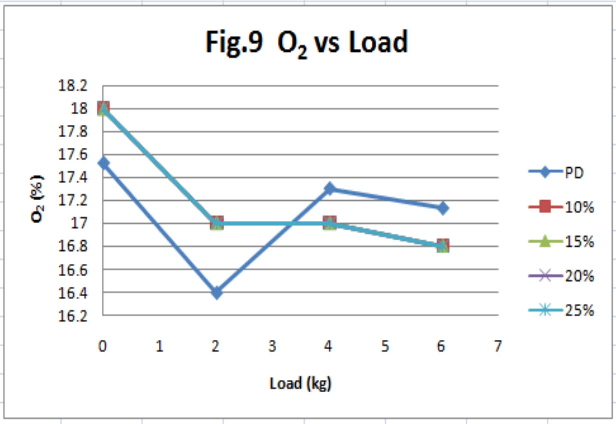


Graph -7: % of CO_2 at different loads

(d) % of O_2: It increases with the increase in % of biodiesel by 11%.

Table -8: % of O_2 at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	16	18	18	18	20
2	15	17	17	17	19
4	13	17.36	17	17	19
6	12	17.13	17.13	17.13	18

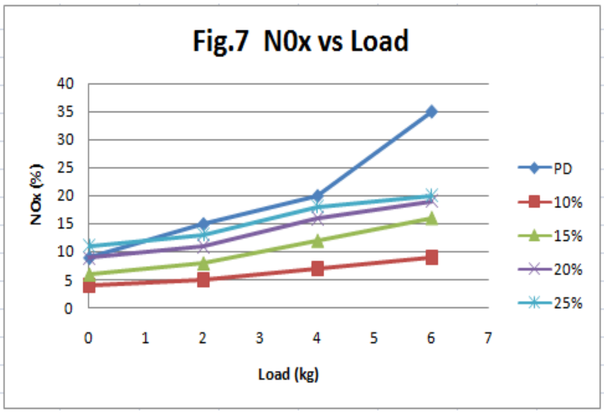


Graph -8: % of O_2 at different loads

(e). % of NO_X: It decreases with the increase in biodiesel by 15 %.

Table -9: % of NO_X at different loads

LOAD	PD	10BD	15BD	20BD	25BD
0	9	6	6	9	11
2	10	8	8	11	13
4	20	12	12	16	18
6	35	16	16	19	20



Graph -9: % of NO_X at different loads

6. CONCLUSIONS

Mustard bio diesel was tested in directed injection diesel engine. Conclusion on test results is that as engine performance and emissions are concerned, mustard oil can be effectively used as source for commercial products of biodiesel. Negative effects of bio diesel properties on brake efficiency can be mitigated without engine modifications i.e., by biodiesel reformulation or additives information. In this research extensive experimental data was obtained on fuel injection and combustion characteristics.

- It is concluded from this research work that, by using blends of biodiesel of WCO
- The BP of engine reduces by 5~11 %.
- The brake thermal efficiency increases by 8.8~13 %.
- The SFC decreases by 7~9 %.
- The percentage of CO reduces by 27~33 %.
- The percentage of CO_2 reduces by 2~5 %.
- The percentage of O_2 increases by 11~15 %.
- The percentage of NO_X reduces by 15~18 %.
- The performance evaluation indicates that use of biodiesel of WCO certainly is beneficial to environment due to reduction in emissions of green house gasses.
- The using of biodiesel of WCO certainly helps in reducing cost of imports of crude oil.

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BIOGRAPHIES

Mr. B. Arun kumar pursuing Mechanical Engineering, 4th year 2nd semester from Avanthi Institute of Engineering and Technology, Makavarapalem, Visakhapatnam, Andhra Pradesh, India.

Mr. G. Mohan pursuing Mechanical Engineering, 4th year 2nd semester from Avanthi Institute of Engineering and Technology, Makavarapalem, Visakhapatnam, Andhra Pradesh, India.

Ms. K.S Sirisha pursuing Mechanical Engineering, 4th year 2nd semester from Avanthi Institute of Engineering and Technology, Makavarapalem, Visakhapatnam, Andhra Pradesh, India.

Ms. K.S Haritha vaishnavi pursuing Mechanical Engineering, 4th year 2nd semester from Avanthi Institute of Engineering and Technology, Makavarapalem, Visakhapatnam, Andhra Pradesh, India.

Mr. A N S Surya Prakash presently working as Asst. Professor Avanthi Institute of Engineering and Technology. He did his M. tech in Machine Design from Sai Ganapathi Engineering College, Andhra Pradesh. He has published several papers in National & International Journals.